

Measurement of low mass dielectron continuum in $\sqrt{s_{NN}}=200\text{GeV}$ Au+Au collisions in the PHENIX Experiment at RHIC

Alberica Toia¹ for the PHENIX Collaboration

Stony Brook University, NY 11794-3800, USA

Received: date / Revised version: date

Abstract. The first measurement of the dielectron continuum at RHIC energies was performed by the PHENIX experiment for Au+Au collisions at $\sqrt{s_{NN}}=200\text{ GeV}$. Mass spectra for different centralities are presented and compared with the expectations from hadron decays.

1 Introduction

Electromagnetic probes are ideally suited to investigate hot and dense matter produced in high energy heavy ion collisions because they do not undergo strong interactions and thus probe the time evolution of the collision. The dielectron continuum is rich in physics. In the low mass region Dalitz decays of light hadrons and direct decays of vector mesons, which might be modified in the medium contribute to the spectrum. A number of experiments (E325[1], DLS[2], CERES[3] and more recently NA60[4]), independent of bombarding energy, have observed an excess of dielectron yield over the hadronic sources by a factor 2-3 for masses between 0.2 and 0.8 GeV/c^2 , when going from proton to heavy ion induced reactions. This enhancement has been interpreted as thermal radiation from pion annihilation in the hot fireball largely mediated by light vector mesons ρ , ω and ϕ . Among these, the most important contribution arises from the ρ meson, due to its strong coupling to the $\pi\pi$ channel and its short lifetime of only 1.3 fm/c which, in contrast to the longer living ω (23.4 fm/c) and ϕ (44.4 fm/c), makes it very suitable to probe in-medium modification close to the QCD phase boundary.

In the intermediate mass region between the ϕ and the J/Ψ vector meson the dominant contribution arises from correlated charm production. This region has been proposed as an interesting candidate to search for thermal radiation emitted as a blackbody radiation from the QGP, since its contribution could be comparable to that of the charm and would be dominant to higher p_T [5]. Earlier measurements [6] indicate an excess of yield in nuclear reactions with respect to the rate expected from elementary reactions. More recently NA60 [7] has disentangled the prompt dimuons from the pairs originated from open charm semi-leptonic decays and demonstrated the prompt origin of the excess yield.

Although correlated e^+e^- pairs are rare, the 0.24 nb^{-1}

collected by PHENIX for Au+Au collisions at $\sqrt{s_{NN}}=200\text{ GeV}$ in 2004 provide a significant sample to investigate the dilepton continuum. In the following, the analysis of 800M events is presented.

2 Di-Electron Analysis

The PHENIX detector design is optimized for electron measurements. It combines an excellent mass resolution (1%) with a powerful particle identification achieved by matching the reconstructed tracks with the information from a Ring Imaging Cherenkov detector (RICH) and an Electromagnetic Calorimeter (EMC). Electrons are identified by requiring at least 3 phototubes matched in the RICH and by correlating the energy measured in the EMC and the momentum, parametrized in terms of $\frac{E-p}{p}$. Pair cuts are applied to avoid sharing of detector hits, tracks which are parallel in the RICH are rejected by a cut on the angular difference. Whenever encountering such a pair, the complete event is rejected.

Pairs are created by combining all electrons with all positrons in one event. The overwhelming yield of these pairs is unphysical. A statistical procedure is used to determine this combinatorial background. Since the PHENIX acceptance is different for like and unlike sign pairs, the combinatorial background is computed with a mixed-event technique by pairing un-like sign tracks from different events within similar topology (i.e. vertex position and collision centrality). The like-sign pairs prove that the shape of the background is reproduced with high precision by the mixed event technique, since the ratio of the like-sign spectra for real and mixed events deviates from 1 by less than 0.1%.

Four different methods have been tested to normalize the background distributions. One normalizes the number of mixed events to the number of physical events. The second one relies on the mean number of single electron tracks

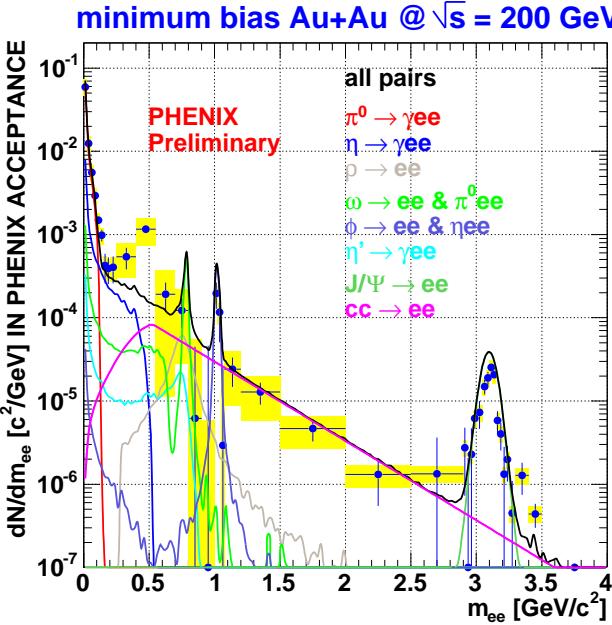


Fig. 2. Data compared to a cocktail from all the hadronic sources. The systematic uncertainty of the data is shown in the band around the data points.

A significant signal is left over the full mass range, corresponding to an integral of $1.8 \cdot 10^5$ pairs, out of those 15,000 above the π^0 mass. The data have been compared to a cocktail of hadron decay sources. The pion spectrum used as input is determined by a parametrization of PHENIX charged and neutral pions. The spectra of the other mesons are determined from the pion spectrum by m_T scaling [8], i.e. using the same Hagedorn parametrization as for pions and replacing p_T with $\sqrt{p_T^2 + m_{meson}^2 - m_{\pi^0}^2}$. The normalization of the yield relative to π^0 is determined by the asymptotic ratio at high p_T (5 GeV/c is used here) [9] [10].

The systematic error, depending on the pion yield and the relative cross section of the other contributions, varies from 10 % to 25 %.

An additional source of dielectron pairs, which becomes the dominant continuum contribution for invariant masses above 0.5 GeV/ c^2 is the correlated charm production. This contribution has been simulated with PYTHIA, scaling the p+p equivalent $c\bar{c}$ cross section of $622 \pm 57 \pm 160$ μ barn to the number of minimum bias Au+Au binary collisions [9]. However it is worth to recall that the single electron measurement [11] shows a suppression at high p_T which increases with centrality. The implications for a dielectron invariant mass are not straightforward, since the invariant mass implies knowledge both of the momentum of the two electrons and the opening angle of the pair. The charm curve here is meant more as an indication than as a real quantity to compare with. The systematic error on the charm is therefore meant as an error on the $c\bar{c}$ cross section only, not on the shape. The calculated electron pairs from charm as well as from the cocktail, have been filtered

into the PHENIX acceptance.

Figure 2 shows the data with the total systematic error

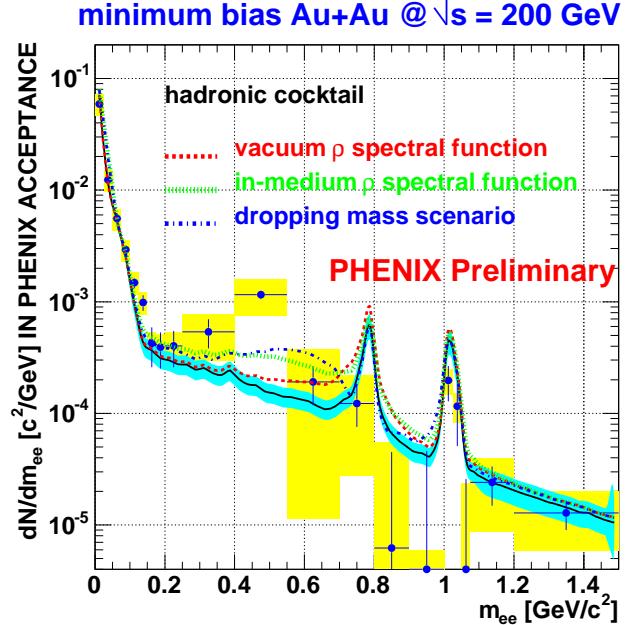


Fig. 3. Data (systematic uncertainty in the band around the points) compared to the cocktail (systematic uncertainty in the band around the spectral function) and theoretical predictions, where a ρ spectral function is introduced, in vacuum, with a dropping or melting scenario.

compared to the cocktail. The data show a good agreement with the cocktail over the full mass region. The ω and ϕ resonances are not fully reproduced, most likely because of the combined effect of mass resolution and low signal-to-background ratio. The data overshoots the cocktail in the region 0.3-0.8 GeV/ c^2 . The systematic uncertainty however does not allow any strong conclusive statement.

In Figure 3 the data have also been compared to the theoretical predictions [12],[5], where the e^+e^- invariant mass spectrum dN_{ee}/dM has been calculated using different in-medium ρ spectral function and an expanding thermal fireball model. Although the systematical uncertainty does not allow any claim of a significant deviation from the known expected sources, it is interesting to observe that the data are even above the predictions that include in-medium modifications in the same mass region where other experiments quantified the same effect.

4 Centrality dependency

Despite the low statistical significance of the dielectron signal, the centrality dependency of the dielectron continuum has been studied. The centrality of the collision is determined using the combined information of the Beam-Beam Counter Detectors and the Zero-Degree Calorimeter

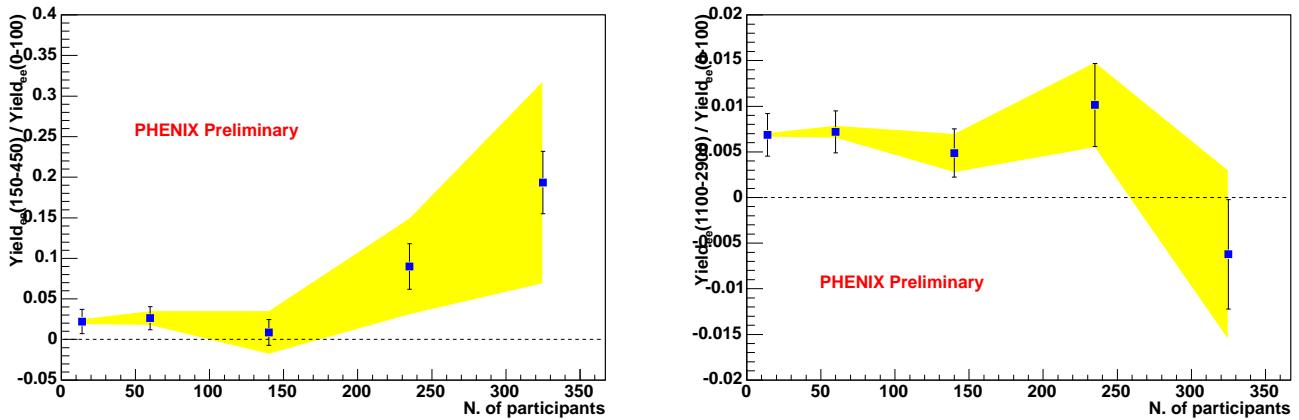


Fig. 5. Ratio of integral of the mass region $150-450 \text{ MeV}/c^2$ (left) and $1.1-2.9 \text{ GeV}/c^2$ (right) with respect to the π^0 yield ($0-100 \text{ MeV}/c^2$). The systematic error, which depends on the combinatorial background in the region $1.1-2.9 \text{ GeV}/c^2$ is indicated by the band. Note the different scale in the two plots.

12. R.Rapp, Phys. Rev. C 63 054907 (2001).
13. J.Kamin, these proceedings